

# Price Relationships along the Value Chain: An Analysis of the Hake Market in France

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**Abstract.** In this paper we use cointegration analysis and the Law of One Price to test for proportionality between hake prices at different stages along the value chain in the French hake market. Cointegration analysis is an appropriate means of testing for price proportionality when price series are non-stationary, as was found to be the case for hake prices in France. Estimates of the relative size of mark-ups along the value chain are calculated by applying the Law of One Price to the cointegrated price series. Finally, we test for weak exogeneity of hake prices in order to determine how price information is transmitted through the value chain.

**Keywords:** Cointegration, Proportionality, Exogeneity, Hake, Market Chains

## 1 INTRODUCTION

For most agricultural and seafood products there are intermediaries between the primary producer and the consumer, such as processors and retailers. These intermediaries have their own production technologies, and will respond to changes in relative prices. Hence, changes in consumer demand will, in general, be distorted down the value chain, so that derived demand for the primary product differs substantially from consumer demand. However, when prices are proportional along the value chain, as was demonstrated in Asche *et al* (1998), consumer demand elasticities and derived demand elasticities coincide. Hence, one can use lower level data to gain information about consumer demand. Furthermore, one can test whether the two elasticities are equal using only price data (for a more in depth discussion of derived demand see Asche *et al* 1998).

In this paper we are interested in determining the relative size of mark-ups along the value chain, and how price information is transmitted through the value chain. In order to do this we apply cointegration theory, and tests related to the Law of One Price (LOP), to data on French hake prices at the retail, wholesale and auction level. The French market was chosen for this analysis because a reliable set of data was readily available.

The paper will be organised as follows. In section 2, a brief overview of the techniques of cointegration and the application of the LOP in determining the relative size of mark-ups along the value chain is given. Next, the characteristics of the French hake market are presented, along with a description of the data used in the analysis. In section 4, the results of the analytical tests are presented.

Finally, in section 5, a brief discussion of the results is undertaken and some concluding remarks are made.

## 2 COINTEGRATION AND THE LAW OF ONE PRICE

It has been observed that most macro-economic time series data are inherently non-stationary. That is, their means, variances or co-variances vary over time. Regressing such non-stationary time series can often lead to spurious correlation, where strong relationships between two or more variables is caused by statistical fluke or model specification issues rather than by meaningful underlying causal relationships.

Cointegration analysis permits inference of causal long run relationships between non-stationary variables and has become the most commonly used methodology for delineating markets (Ardeni 1989; Goodwin and Schroeder 1991; Gordon, Salvanes and Atkins 1993; Asche, Salvanes and Steen 1997; Perez Agundez *et al* 1999). The economic interpretation of cointegration is that “if two (or more) series are linked to form an equilibrium relationship spanning the long-run, then even though the series themselves may contain stochastic trends (i.e., be non-stationary) they will nevertheless move closely together over time and the difference between them will be stable (i.e., stationary)” (Harris 1995, p.22). When cointegration is verified, variables exhibit stable long run relationships, which indicate that a price parity equilibrium condition exists and variables are part of the same market.

### 2.1 Testing for stationarity

A prerequisite for undertaking cointegration tests is to verify that the series is, in fact, non-stationary and to ascertain the variables’ integration order.

The most commonly used test for determining whether a series is nonstationary is the Augmented Dickey-Fuller (ADF) unit root test. In this test, a null hypothesis is imposed that the data are non-stationary (ie. contain a unit root) against the alternative hypothesis of being a stationary variable.

Mathematically, the ADF can be expressed as testing  $H_0 : \alpha_0 = 0$  against  $H_1 : \alpha_0 < 0$  from the following general model:

$$\Delta Y_t = \alpha_0 \cdot Y_{t-1} + \sum_{i=1}^{p-1} \alpha_i \cdot \Delta Y_{t-i} + c + \delta \cdot t + \eta_t$$

with  $\eta_t \sim IID(0, \sigma^2)$  (1)

Differencing a non-stationary variable generally results in a stationary variable. However, sometimes a series must be differenced several times before it becomes stationary, although it is argued that this procedure may lead to the loss of short-run information. If a series is differenced  $d$  times before it becomes stationary, thus containing  $d$  unit roots, it is said to be integrated of order  $d$  and is denoted as being  $I(d)$ . Variables that are stationary in their levels, ie.  $I(0)$  should be discarded from cointegration analysis. In most cases it is not strictly necessary for all the variables in question to have the same order of integration (Harris 1995).

## 2.2 Testing for cointegration

There are many alternative tests for cointegration, but it is well documented that the multivariate vector regression (VAR) approach developed by Johansen (1988) performs better than the single equation approach and other multivariate methods in detecting cointegration. This methodology has become widely used in most recent market delineation studies. See, for example, Clay and Fofana (1999); Perez Agundez *et al* (1999) and Asche and Steen (1998).

The multivariate approach developed by Johansen starts by defining a vector of  $n$  potentially endogenous variables  $Z_t$ . It is assumed that  $Z_t$  is an unrestricted VAR system with up to  $k$ -lags:

$$Z_t = A_1 Z_{t-1} + \dots + A_k Z_{t-k} + \Phi D_t + \mu + \varepsilon_t \quad (2)$$

where  $A_i$  is an  $n \times n$  matrix of coefficients,  $\mu$  is a constant,  $D_t$  are seasonal dummies orthogonal to the constant term  $\mu$  and  $\varepsilon_t$  is assumed to be an independent and identically distributed Gaussian process.

Equation (2) can be reformulated in vector error-correction (VECM) form by subtracting  $Z_{t-1}$  from both sides:

$$\Delta Z_t = \Gamma_1 \Delta Z_{t-1} + \dots + \Gamma_{k-1} \Delta Z_{t-k+1} + \Pi Z_{t-k} + \Phi D_t + \mu + \varepsilon_t \quad (3)$$

where,  $\Gamma_i = -(I - A_1 - \dots - A_i)$ , ( $i = 1, \dots, k-1$ ), and  $\Pi = -(I - A_1 - \dots - A_k)$ .

The system of equations specified in (3) now contains information on both the short-run and the long-run adjustment to changes in  $Z_t$ . The rank of  $\Pi$ , denoted as  $r$ , determines how many linear combinations of  $Z_t$  are stationary. If  $r=N$ , the variables in levels are stationary; if  $r=0$  so that  $\Pi=0$ , none of the linear combinations are stationary. When  $0 < r < N$ ,  $r$  cointegration vectors, or  $r$  stationary linear combinations of  $Z_t$  exist. In this case one can factorise  $\Pi$ ;  $\Pi = \alpha\beta'$ , where  $\alpha$  represents the speed of adjustment to dis-equilibrium and  $\beta$  is a matrix of long-run coefficients and contains the cointegration vectors. Determining how many cointegration vectors exist in  $\beta$  consequently amounts to testing for cointegration.

Johansen and Juselius (1990) show that after undertaking appropriate factorising and by solving an eigenvalue problem it is possible to test for the number of significant cointegration vectors using two different tests. The first is the trace test ( $\eta_r$ ), which is a likelihood ratio test for at most  $r$  cointegration vectors using

$$\eta_r = T \cdot \sum_{i=r+1}^N \ln(1 - \lambda_i), \text{ where } T \text{ is the number of}$$

observations and  $\lambda_i$  are the eigenvalues which solve the eigenvalue problem. The second is the maximum eigenvalue test ( $\xi$ ), which is a test of the relevance of column  $r+1$  in  $\beta$  using  $\xi_r = -T \ln(1 - \lambda_{r+1})$ .

As the trace test tends to accept cointegration too often (Johansen and Juselius 1990), we will accept cointegration in accordance with the maximum eigenvalue test. Maddala and Kim (1998) suggest that the maximum eigenvalue should be corrected for the number of estimated parameters (degrees of freedom)<sup>1</sup>.

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1 The Johansen  $\lambda_{\max}$  test statistic should be corrected for the number of estimated parameters. This is done by multiplying it by  $(T - np)/T$ , where  $T$  is the number of observations,  $n$  is the number of variables, and  $p$  is the number of lags (Maddala and Kim 1998, p. 219).

### 2.3 Testing for price proportionality

The LOP is usually tested for by running the regression:

$$\ln p_t^1 = \gamma + \beta \ln p_t^2 + \varepsilon_t \quad (4)$$

and testing the null hypothesis  $H_0: \beta = 1$ , where  $p_1$  and  $p_2$  are the prices of goods 1 and 2 respectively.

If  $\gamma = 0$  and  $\beta = 1$ , then the two prices are equal. This is the strict version of the LOP. If  $\gamma \neq 0$ , but  $\beta = 1$ , the prices have a proportional relationship, but their levels differ due to factors such as transportation costs and quality differences.

When the price series under observation are nonstationary, it is not possible to test for the LOP using this method. Instead, one must use cointegration theory, and the Johansen procedure (see section 2.2). Restrictions are imposed on the parameters in the cointegration vectors  $\beta$ , using likelihood ratio tests<sup>2</sup>.

In this paper we are testing for the existence of a common cointegrating vector for two price series. Hence, there are two price series in the  $Z_t$  vector. Provided that the price series are cointegrated, the rank of  $\Pi = \alpha\beta'$  is equal to one and  $\alpha$  and  $\beta$  are  $2 \times 1$  vectors. A test of LOP is then a test of whether  $\beta' = (1, -1)$ .

Even if  $\beta' \neq (1, -1)$ , the parameter  $\beta$  is still of interest as it measures the price transmission elasticity at different points along the value chain. That is, the percentage change in the consumer price in response to a one percent change in the input factor price.

2 The null restrictions on the long run parameters in  $\hat{\beta}$  are tested using a likelihood ratio test. First the model is estimated in its unrestricted form and the unrestricted eigenvalues obtained,  $\hat{\lambda}_1 > \dots > \hat{\lambda}_r$ , where  $\hat{\lambda}_i$  is the eigenvalue of the  $i^{\text{th}}$  vector from the unrestricted cointegrating space. Then the model is estimated in its restricted form and the restricted eigenvalues obtained,  $\hat{\lambda}_i^* > \dots > \hat{\lambda}_r^*$ . Finally the two sets of eigenvalues are compared by calculating the test statistic given by;

$$LR^*[r(N-s)] = T \sum_{i=1}^r \ln \left\{ 1 - \hat{\lambda}_i^* / 1 - \hat{\lambda}_i \right\}. \quad \text{The test}$$

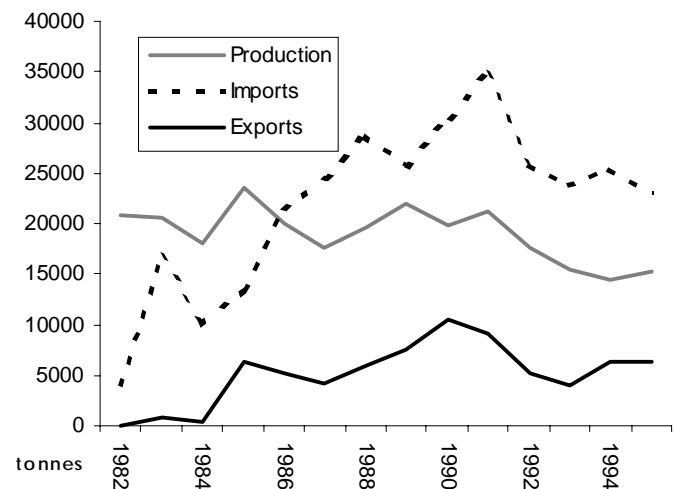
statistic has an asymptotic chi-square distribution with  $r(N-s)$  degrees of freedom, where  $r$  is the number of cointegrating vectors,  $N$  is the dimension of the unrestricted cointegration space and  $s$  is the dimension of the restricted space.

### 2.4 Testing for weak exogeneity of prices

Using the Johansen procedure we can also test for weak exogeneity of prices. In order to do this we impose restrictions on parameters in the  $\alpha$  vector using likelihood ratio tests. If a row in  $\alpha$  contains only zeros (in our case one element since  $\alpha$  is a column vector) the price in question will be weakly endogeneous. That is, it will determine the other price. Testing for weak exogeneity amounts to testing the null hypothesis  $H_0: \alpha = 0$ .

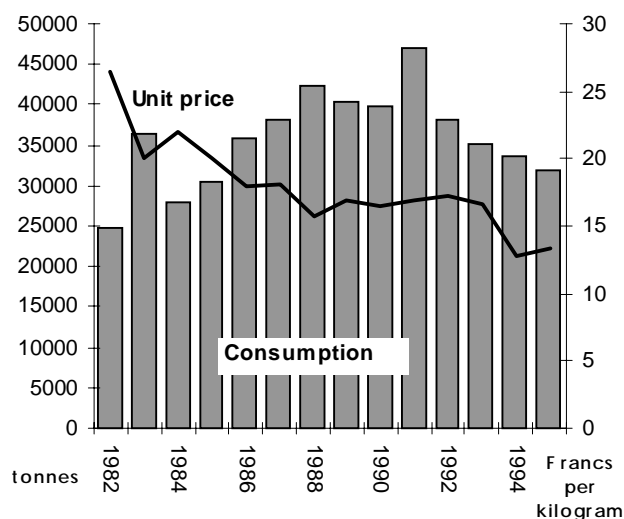
## 3 THE FRENCH HAKE MARKET

Historical developments in the French hake market are illustrated in Figure 1. Most notable is the increase in exports since 1985. The majority of these exports are to Spain. Export volumes to Spain increased in 1995 in response to shortfalls in production brought about by the closure of Namibian fisheries to Spanish fisherman in 1990. Around half of total French hake production is exported to Spain as fresh product (Le Grel *et al* 1998).



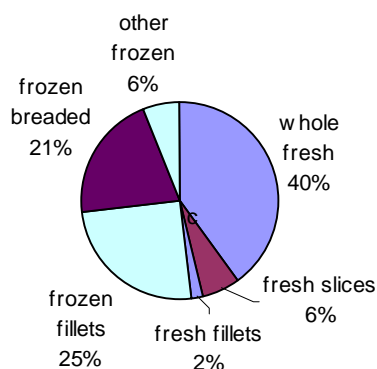
**Figure 1** Historical development of the French market for hake

In 1995, France accounted for roughly 7 percent of total European hake consumption (Le Grel *et al* 1998). The largest consumer of hake in Europe is Spain, accounting for around two thirds of the total European market (FAO 1997).



**Figure 2** Consumption and real unit price of consumption (1995 francs) in the French hake market

The market for hake in France is relatively small, with a mean market share of 3.2 per cent in value between 1982 and 1995 (Le Grel *et al* 1998). Consumption of hake in France increased between 1982 and 1991. However, since 1991, it has fallen despite lower per unit prices (Figure 2). Roughly 40 per cent of total hake consumption in France is made up of whole fresh hake, with the remainder composed mainly of frozen products (Figure 3).

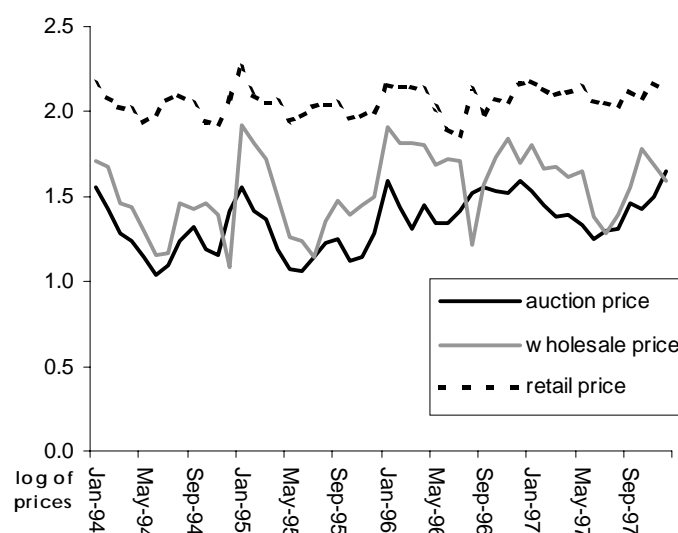


**Total consumption = 31908 tonnes**

**Figure 3** Percentage share of market by product form 1997  
Hake, in its various product forms, is distributed fairly widely across the many different types of retail outlets in France. For example, whole fresh hake and sliced hake are

sold through multiple grocers, fishmongers and directly. In 1994, multiple grocers sold 36 per cent of total whole hake, fishmongers sold 29 per cent and direct sales were 26 per cent. For sliced hake, multiple grocers sold 21 per cent, fishmongers sold 46 per cent and direct sales were 26 per cent (Le Grel *et al* 1998).

The prices used in this analysis are for whole fresh hake sold at retail, wholesale and auction in France. Prices are monthly between January 1994 and December 1997<sup>3</sup>. For retail prices, product sold through hyper-markets is taken to be representative of the price received for whole fresh hake at retail. Wholesale prices are for product sold through the Rungis market in Paris. The price series are graphed in Figure 4.



**Figure 4** Monthly hake prices January 1994 – December 1997

It is clear from this figure that there are two problematic data points in the price series for hake sold at the wholesale level. That is, in December 1994 and August 1996, wholesale prices were below auction prices.

#### 4 APPLICATION TO THE MARKET FOR HAKE IN FRANCE

In the first part of this section we use cointegration tests to determine whether prices are related at each different stage of the value chain for hake in France. Next we use the LOP to test whether prices are proportional along the value chain. In the instance that they are not proportional we

<sup>3</sup> Data were provided by Jose Perez-Agundez – personnel communication.

apply the LOP to calculate the price transmission elasticity. Finally, we test for weak exogeneity of prices in order to determine in which direction price information is transmitted along the value chain.

#### 4.1 Stationarity tests

ADF tests for stationarity were performed on each of the three price series. Two separate ADF equations were used to test for unit roots. The first equation includes only a constant term, while the other includes both a constant and a trend term. The results of the ADF tests applied to the price series in levels and in first differences are presented in Table 1.

**Table 1** Results from the ADF test

Country	ADF test (constant included)	significant lag	ADF test (constant and trend included)	significant lag
<b>Levels of price series</b>				
Auction	-1.99	1	-3.06	1
Wholesale	-2.84	1	-3.00	1
Retail	-2.86	3	-3.49	1
<b>First difference of price series</b>				
Auction	-3.21*	3	-4.46**	1
Wholesale	-3.39*	10	-3.94*	3
Retail	-3.91**	11	-4.07*	5

Critical values for ADF test (constant included): 5%=-2.953 and 1%=-3.642. Critical values for ADF test (constant and trend included): 5% = -3.551 and 1%=-4.26.

\*\* Indicates significant at 1%, \* Indicates significant at 5%.

The ADF tests indicate that all series are non-stationary and I(1). In addition, removing the trend term from the ADF equations increases the number of non-stationary lags in the levels.

#### 4.2 Cointegration results

All price series were found to be I(1), hence all are included in the Johansen tests for cointegration. These tests are carried out pairwise between each set of prices along the value chain. Based on the outcome of the ADF tests, there does not appear to be a trend in the price series for hake at the auction, wholesale or retail level in France, hence trend will initially be excluded from the cointegration space.

Before undertaking cointegration tests, OLS regressions were run for each of the price series in order to determine whether there were any outliers in the data, and hence, whether to include dummy variables in the short-run model.

An investigation of residual plots from OLS estimation of each price series was undertaken following the methods outlined in Harris (1995). These plots revealed that there were significant outliers in the price series for hake sold at the retail level<sup>4</sup>. There is no *a priori* evidence as to why these outliers are present in the data series, however dummy variables were added, which were found to be significant on re-estimation of the OLS equations. The inclusion of dummy variables in the cointegration space removed all diagnostic problems from the models.

The estimation of OLS equations also made it possible to determine the number of lags to be included in the cointegration space for each bivariate test, and whether to include seasonal components. Seasonal components were found to be important in all three price series.

The results of the Johansen tests, reported in Table 2, indicate that the auction price is cointegrated with both wholesale and retail prices, and that, in addition, wholesale prices are cointegrated with retail prices.

Now that we have established that there is a causal relationship between prices along the value chain, we test for proportionality between prices at different levels. More specifically, we are interested in determining whether agents at each level along the chain are responding to the same relative prices, that is, mark-ups are constant, or whether they are responding to different price signals. The results reported in Table 2 for the chi-square test for price proportionality indicate that prices are proportional between the auction and wholesale level but not between the wholesale and retail level, or between the auction and retail level. Further tests on  $\beta$  reveal that the price transmission elasticity between the wholesale and retail level is 2.94, and between the retail and auction level it is 3.89.

Now that we have established the relative size of mark-ups along the value chain, we will attempt to determine in which direction price information is transmitted through the chain. We do this by undertaking tests for weak exogeneity, the results of which are reported in Table 3.

We can see that auction prices are weakly exogenous in their relationship with both wholesale prices and retail prices. This would imply that both retail and wholesale prices are determined by auction prices. Given that auction prices and wholesale prices are proportional, this indicates that a one percent change in the auction price of hake in France would bring about a one percent change in prices at the wholesale level.

4 In the retail price series there were significant outliers in June and July 1996.

**Table 2** Johansen test for the French hake market

Ho: rank = p	Max test	Max test (adjusted for degrees of freedom)	Critical value (95%)	Trace test (adjusted for degrees of freedom)	Trace test	Critical value (95%)	Proportionality
<b>Auction and wholesale price<sup>1</sup></b>							
p = 0	32.6**	31.21**	14.1	33.72**	32.28**	15.4	0.56
p ≤ 1	1.12	1.07	3.8	1.12	1.07	3.8	
<b>Wholesale and retail price<sup>2</sup></b>							
p = 0	33.19**	28.66**	19.0	33.96**	29.33*	25.3	26.02**
p ≤ 1	0.77	0.67	12.3	0.77	0.67	12.3	
<b>Auction and retail price<sup>3</sup></b>							
p = 0	32.3**	29.29**	19.0	41.71**	37.83**	25.3	11.7**
p ≤ 1	9.41	8.53	12.3	9.41	8.53	12.3	

\*\* Indicates significant at 1%, \* Indicates significant at 5%.

Notes: 1. System estimated for 1 lag. A seasonal component and a constant term were included in the cointegration space over the long run.

2. System estimated for 3 lags. A seasonal component and a constant term were included in the cointegration space over the long run and a trend was included in the short run. 3. System estimated for 2 lags. A seasonal component and a constant term were included in the cointegration space over the long run and a trend was included in the short run.

**Table 3** Tests for weak exogeneity

Price	Potentially exogeneous price	Test statistic
Auction	Wholesale	14.779**
Wholesale	Auction	1.775
Wholesale	Retail	29.344**
Retail	Wholesale	8.543**
Auction	Retail	18.86**
Retail	Auction	0.012

\*\* Indicates significant at 1%, \* Indicates significant at 5%.

In the case of wholesale and retail prices, it was found that neither of these prices were exogeneous. Hence, it is not possible to infer in which direction price signals are transmitted between these two levels. However, it is likely that they are determined by prices at other points along the value chain.

Based on earlier tests of price transmission elasticities we found that there was a price transmission elasticity between auction and retail of 3.89. Given that auction prices are weakly exogeneous in their relationship with retail prices, this implies that a one percent change in prices at auction will bring about a 3.89 per cent change in prices at retail.

## 5 CONCLUSION AND DISCUSSION

Our results suggest that there is a relationship between prices for whole fresh hake at the auction, wholesale and retail levels of the value chain in France. Moreover, prices are proportional between the auction and wholesale level, but not between the wholesale and retail level or the auction and retail level. This would tend to imply that agents at the auction and wholesale level are responding to the same relative prices. But that price signals become distorted higher up the chain, between the wholesale and retail level.

Tests for weak exogeneity revealed that the direction of price signals was from auction to wholesale and from auction to retail. However, in the case of wholesale and retail prices neither price was exogeneous. In this case, it is likely that prices are determined at a different point along the value chain.

Further analysis of the market for hake in France may reveal why prices are not proportional between wholesale and retail. In addition, adding more steps along the value chain would be useful, if this price data were to become available, as it would allow us to establish other factors which are important in describing the relationship between consumer demand and derived demand.

Given that we have found a proportional relationship between prices at auction and wholesale, it would be possible to use auction prices to obtain information about demand at the wholesale level. However, this is not possible for prices higher up the chain. That is, we cannot use auction, wholesale or retail prices to obtain information about consumer demand.

## 6 ACKNOWLEDGEMENTS

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